Internet program for facilitating dietary modifications limiting kidney stone risk

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Introduction: *Certain dietary modifications limit the risk of stone recurrence. Compliance is an important component of dietary therapy for stone prevention, and self-efficacy is an important ingredient of compliance. We developed an internet program to facilitate dietary compliance for stone prevention and performed a pilot study to assess its effectiveness.*

Materials and methods: *The internet program provides information regarding dietary modifications including increased fluid consumption, limited animal protein, sodium, and oxalate intake, and adequate calcium consumption. Participants record their daily food and fluid intake and receive immediate feedback as to whether they were compliant or not. Five adult calcium stone formers collected three 24 hour urine specimens on self-selected diets, three 24 hour urine specimens while on a stone preventive metabolic diet, and three 24 hour urine specimens after utilizing the internet program for 1 month. Urinary stone risk parameters were measured, and data were analyzed using repeated measures ANOVA and Student's t test.*

Results: *All participants recorded their meals and snacks for each day and found the program easy to navigate. The mean time in hours from food consumption to log in was 35.25 ± 70.8 hours. There were no statistically significant differences in stone risk factors between the controlled and internet dietary phases. Oxalate excretion was significantly higher during the self-selected dietary intake ($p = 0.03$).*

Conclusions: *This pilot study demonstrates that subjects appear to be compliant with utilization of an interactive internet program for stone prevention with dietary modifications. In addition, improvement in certain stone risk parameters occurred.*

Key Words: oxalate, calcium, internet, nephrolithiasis, diet

Introduction

Diet is known to have a significant impact on kidney stone formation, and modifying it can attenuate stone risk. Patients need to be instructed on how to appropriately adjust their diets for stone prevention. This information can be conveyed by the treating physician, a physician extender, a nurse or nursing assistant, or a registered dietitian. Educational handouts alone or combined with verbal instructions are also utilized by some practitioners, and the latter has been shown to be an effective method in retrospective studies.[1] Some patients use the internet for accessing health information, but inaccurate information may be present in the accessed websites.[2,3] Compliance is necessary for dietary measures to be effective. While regular interactions with a registered dietitian are one method to enhance compliance, such services may not be covered by insurance carriers, dissuading the patient from pursuing this type of dietary reinforcement.

Calcium oxalate stones are the most common type formed, and the majority of dietary recommendations

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for stone formers have been targeted for this patient cohort.[4] Patients are directed to increase fluid consumption as a means of limiting the supersaturation of calcium oxalate in urine via dilution. Limiting the consumption of sodium and animal protein is also advocated, as this has been demonstrated to attenuate the excretion of calcium in urine.[5-7] Approximately 50% of urinary oxalate is derived from dietary oxalate consumption, and limiting its intake has been demonstrated to reduce its urinary excretion.[8] In contrast, a reduction of dietary calcium consumption to below the daily recommended intake is not advised, as this increases urinary oxalate excretion and hence stone risk.[8,9]

Interactive internet programs have been developed to facilitate the management of certain diseases such as diabetes mellitus, chronic obstructive pulmonary disease, and tinnitus, and these programs have been demonstrated to be effective.[10-12] They promote self-efficacy, the sense of being able to accomplish a goal, in the participant, and this enhances compliance. In addition, self-monitoring, measurement of one's own behavior, is an important component of these programs. Self-monitoring is an effective tool for promoting behavioral changes, as it facilitates one's awareness of progress made toward an identified goal and provides direct feedback. The impact of self-monitoring has been illustrated in various lifestyle modification studies. A meta-analysis of physical activity trials demonstrated that the effects were greater in studies where self-monitoring was incorporated.[13] In the Women's Health Initiative Dietary Modification Trial, targeted dietary changes were linked to a participant submitting more self-reporting records.[14] Keeping the aforementioned factors in mind, we developed an interactive internet program to facilitate compliance with dietary modifications to limit kidney stone risk, primarily calcium oxalate stones. Herein, we report a pilot study assessing the feasibility of using such a program to implement dietary therapy for stone prevention. The future goal would be to assess this instrument's effect on stone recurrence in a randomized prospective study.

Materials and methods

We created an interactive website that allows participants to record their food and beverage intake on an ongoing basis and receive immediate feedback. The site is password-protected, and its address is https://www.stonestoppers.com/public/tmp_dspLoginForm.cfm. The site is divided into four major sections: 1) an educational section which provides information regarding dietary modifications for prevention of calcium oxalate kidney stones, a listing of food categories, and illustrative menus; 2) the self-monitoring component; 3) the feedback component; and 4) a section answering frequently asked questions. A printed version of the information in the educational section was also provided to all participants.

Dietary recommendations for this program are based on the 2005 United States Health and Human Services and Department of Agriculture Dietary Guidelines for Americans.[15] They also focus on facilitating reduced oxalate consumption while encouraging other modifications for stone prevention, namely adequate fluid and dietary calcium consumption and reduced sodium and animal protein intake. The daily goals are listed in Table 1. Nutrient data is derived from the USDA National Nutrient Database for Standard Reference. Foods are grouped into seven categories: dairy foods and other calcium sources, animal protein sources other than dairy foods, fruits and juices, vegetables, grains, beverages, and miscellaneous. Foods are also classified as either low oxalate (< 4 mg of oxalate per serving), medium oxalate (4 mg-9 mg per serving), or high oxalate (≥ 10 mg of oxalate per serving). Serving sizes are based on common household measurements, and participants were provided measuring cups and spoons and a food scale to support accurate portion control and reporting. The daily program recommendations included 3-4 servings of fruit or juice, 4-6 servings of vegetables, 5-8 servings of grains, one high calcium (> 250 mg per serving) food with each meal, and 5-6 ounces (cooked weight) of animal protein from non-dairy sources. One serving of the medium oxalate choices in each group was permitted daily, and no more than one high

TABLE 1. **Dietary intake**

Dietary parameter	Daily internet goal	Daily controlled diet content
Oxalate	< 75 mg	< 75 mg
Sodium	< 2300 mg	< 2300 mg
Calcium	High calcium (> 250 mg) foods with each meal	1200 mg distributed over 3 meals
Animal protein (non-dairy)	< 6 oz	< 6 oz
Fluids	≥ 2 L	3 L
Fat	Not specified	30% of total calories

oxalate choice from any group was allowed each week. A drop-down list is provided for all food categories, and over 250 foods are listed. Sodium consumption is limited by recommending that foods and beverages used contain no more than 250 mg sodium per serving with no more than two items exceeding that sodium level daily. Calories were not controlled or emphasized, but participants were encouraged to achieve and/or maintain a healthy weight. After subjects submit their food and beverage intake, they can immediately receive feedback as to their progress in meeting the recommended guidelines. This can be done meal by meal, daily, or at any time interval desired by the participant. An e-mail reminder is sent if dietary information is not submitted as scheduled. The internet site also allows participants to submit queries regarding the oxalate contents of foods not on the aforementioned lists.

After obtaining Institutional Review Board approval, five adult recurrent calcium stone formers (two females and three males with a history of calcium oxalate, calcium phosphate, or mixed calcium stones) participated in this pilot study. The patients were devoid of medical problems that could promote stone formation. First, participants collected three 24 hour urine specimens while consuming a self-selected diet. Next, they were placed on a controlled diet prepared in the metabolic kitchen of our Clinical Research Unit, Table 2, for 5 days and collected 24 hour urine specimens on days three through five. After this the patients were given the written information on diet and started to use the program. They then collected three 24 hour urine specimens after 1 month of following the dietary recommendations set forth by the website. Compliance with dietary entry was monitored, and feedback was delivered. While dietary entry was monitored, compliance data were not analyzed in this pilot study. Patients were asked to comment on ease of use of the Internet program. Overall, each participant collected nine 24 hour urine specimens. Urinary stone risk parameters were measured, and data were analyzed using repeated measures ANOVA and Student's t tests.

Results

All participants recorded what they consumed for all 30 days and found the website easy to navigate. Mean participant age was 48.2 ± 8.9 years, and age range was 35-58 years. The mean time from snack or meal time to internet logging time was 35.25 ± 70.79 hours, but four out of five participants had average meal-to-log times of less than 8 hours. This demonstrates that recall bias would likely be minimal. All patients commented that the program was easy to navigate and uploading data was straightforward. There were no statistically significant differences in urinary creatinine, volume, oxalate, calcium, citrate, sodium, potassium, magnesium, phosphate, uric acid, urea nitrogen, or Tiselius index for calcium oxalate supersaturation between the controlled and internet-guided dietary phases when analyzed using repeated measures analysis of variance. Excretions were indexed to gram of urinary creatinine, Table 2.

TABLE 2. **Mean 24 hour urinary parameters for various diet phases**

24 hour urinary parameter (mean ± SD)	Self-selected diet	Controlled diet	Internet-guided diet	p value
Volume (L)	1.7 ± 0.7	2.2 ± 0.7	1.7 ± 0.9	0.09
Creatinine (g)	1.7 ± 0.7	1.7 ± 0.4	1.5 ± 0.4	0.35
Sodium (mg/g Cr)	2471 ± 829	1295 ± 584	2172 ± 798	0.06
Potassium (mg/g Cr)	1563 ± 648	1514 ± 454	1744 ± 805	0.49
Calcium (mg/g Cr)	155 ± 112	157 ± 63	132 ± 59	0.32
Magnesium (mg/g Cr)	1847 ± 849	2028 ± 491	1569 ± 480	0.45
Phosphate (mg/g Cr)	580 ± 146	602 ± 173	582 ± 149	0.74
Oxalate (mg/g Cr)	22 ± 8	16 ± 3	17 ± 5	0.03
Citrate (mg/g Cr)	288 ± 146	276 ± 137	306 ± 186	0.79
Uric acid (mg/g Cr)	360 ± 88	327 ± 134	341 ± 74	0.72
Urea nitrogen (mg/g Cr)	5032 ± 3081	7029 ± 2695	6165 ± 1797	0.21
Tiselius index for CaOx	1.3 ± 0.9	0.8 ± 0.3	0.8 ± 0.2	0.38

Mean urinary oxalate excretion was 22 ± 8 mg/g creatinine on the self-selected diet, 16 ± 3 mg/g on the controlled diet, and 17 ± 6 mg/g on the internet-guided diet. Oxalate excretion was significantly higher while on the self-selected diet ($p = 0.03$), and sodium excretion approached a significantly higher level ($p = 0.06$) as well.

Discussion

Increased urinary calcium and oxalate excretion and reduced urine volume are risk factors for calcium oxalate kidney stone formation.[16,17] Altering dietary habits may limit stone risk and is typically the first approach utilized. A randomized prospective study of first time calcium oxalate stone formers in which one cohort was instructed to increase fluid intake and the other was not demonstrated that the former group maintained higher urine volume and was at significantly lower risk for recurrent stone formation.[18] Another prospective randomized study in which recurrent, hypercalciuric stone formers were randomized to either a low calcium diet or a normal calcium, low sodium, low animal protein diet demonstrated that the latter was associated with fewer recurrences.[19] Calcium excretion declined similarly in both cohorts while oxalate excretion increased in the low calcium diet cohort. The Health Professionals Follow-Up Study and the Nurses' Health Studies 1 and 2 have shown that low dietary calcium consumption and elevated dietary oxalate intake are correlated with the risk of stone formation.[20-23] The Women's Health Initiative study also demonstrated this relationship with dietary calcium and stone risk.[24] Reduced dietary calcium intake has been shown to increase oxalate excretion, and limiting dietary oxalate intake has been demonstrated to significantly attenuate urinary oxalate excretion in controlled metabolic studies.[8,9,19] Limited sodium and animal protein consumption and increased fluid intake have been shown to attenuate stone risk in some of the aforementioned epidemiologic studies.[16,20-22,25] A positive correlation between animal protein consumption and urinary calcium and uric acid excretion has been reported in controlled metabolic studies while there is a negative correlation with citrate excretion.[6,7,26,27] Sodium consumption has been demonstrated to increase calcium excretion and reduce citrate excretion in controlled metabolic studies.[5,28,29] Both promote stone risk. We used the aforementioned findings and responses to design this interactive internet program.

This pilot study demonstrated that patients were compliant with entering dietary data into an internet site for a month period. They found this process to be easy and found the site easy to navigate. The only significant change in stone risk parameters with utilization of this instrument was decreased urinary oxalate excretion. Urinary oxalate excretion indexed to urinary creatinine significantly decreased during the controlled dietary and Internet phases as compared to the self-selected period. Sodium excretion was highest on the self-selected diet and lowest on the controlled diet, and it was lower during internet utilization when compared to the self-selected phase. This suggests that the internet program may facilitate adherence to dietary sodium control. Perhaps modifying the program with more emphasis on sodium intake might improve compliance with sodium consumption. Since no differences were noted in any urinary parameters between the controlled or "ideal" diet and the internet phase, this implies that either being on the controlled diet or using the internet program (or a combination of these two) can promote adherence to an eating pattern that may be beneficial in the prevention of kidney stones. The results may have been more prominent if the subjects had overt hyperoxaluria or hypercalciuria, which they did not. Most subjects had also previously received information regarding dietary modifications as they were recurrent stone formers and thus were not completely "diet naïve."

There is limited information regarding dietary compliance for stone prevention. In the prospective randomized prospective trial of Borghi and associates,[19] subjects who were to consume a low sodium, low animal protein, and normal calcium diet received written information regarding this diet and examples of foods to consume. These patients collected 24 hour urine samples 1 week after receiving these instructions and annually thereafter for 5 years. Urinary sodium was lowest at the 1 week interval and was significantly lower during all 5 yearly collections as compared to baseline. This was also true for urea and sulfate excretion which are surrogates for protein intake. These results suggest that the patients were compliant with dietary modifications throughout the study period but were most compliant during the initial phase of the study. If future studies demonstrate a durable response with this program, it could prove to be a useful tool for facilitating dietary compliance. Data entry into such a website could be accomplished with a "smart phone" in the future, thus improving its practicality.

This investigation has inherent weaknesses, some of which are due to it being a pilot study. A small number of subjects were enrolled, and some were not calcium oxalate stone formers. Despite this, a significant reduction in oxalate excretion as compared to a self-

selected dietary phase was demonstrated. While the level of excretion was in the normal range and the decreases were relatively small, such reductions could lessen stone risk based on prior work.[23] The impetus for a reduction in urinary oxalate excretion and the alignment of other urinary parameters during the controlled diet and internet phases may have been influenced by other factors such as the dietary information provided to the participants on the handout and in the educational section of the website or "dietary imprinting" occurring during the controlled diet. While compliance with dietary entry was monitored, an analysis of non-compliant episodes was not part of this study. Also, ease of website use was not formally assessed but rather commented on by participants. Modifications of this program are being considered after which a larger study in which the latter will be assessed.

Conclusions

This study suggests that an interactive, internet-based program is a feasible method of educating patients about dietary modifications for stone prevention. Further better-designed studies will be needed to test the efficacy of this approach including ones with longer duration, larger cohorts, and comparisons to more traditional methods of dietary education. □

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